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PREDICTING PEAK PRESSURE LEVELS OF SHOULDER-LAUNCHED ROCKETS AN--ETC(U)
MAY 77 G CHAIKIN, G R GARINTHER

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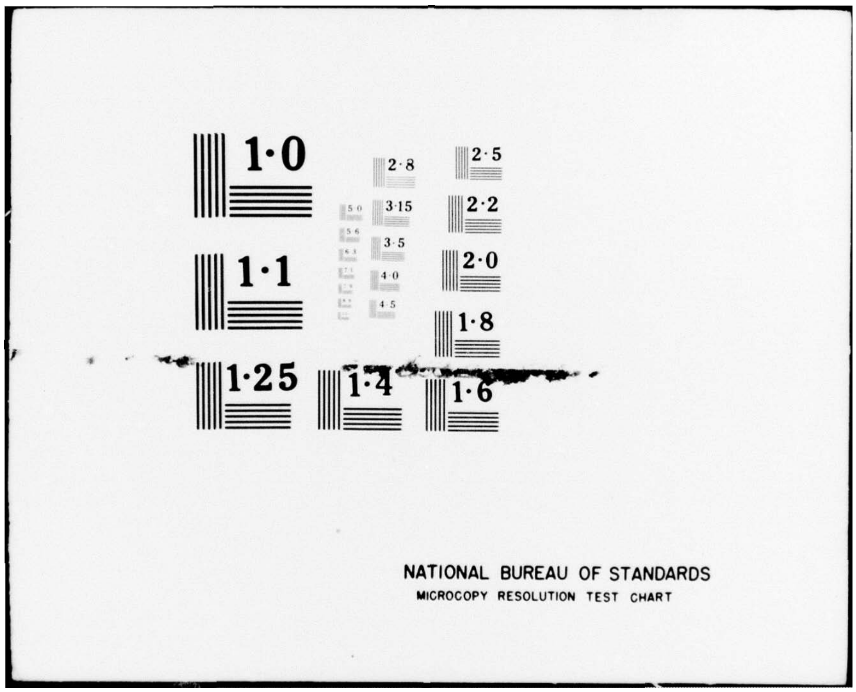
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Technical Note 5-77

PREDICTING PEAK PRESSURE LEVELS OF SHOULDER-LAUNCHED ROCKETS AND MISSILES

Gerald Chaikin
Georges R. Garinther

May 1977
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Based on impulse noise measurements at the gunner position for various proposed and developed shoulder-launched rockets and missiles, a simple relationship was formulated to forecast peak pressure levels of future systems as a function of concept parameters.

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PREDICTING PEAK PRESSURE LEVELS OF

SHOULDER-LAUNCHED ROCKETS AND MISSILES

INTRODUCTION

Up to the present time, initial definitions of impulse noise for shoulder-launched rocket systems have, necessarily, awaited measurements conducted on prototypes. It would be useful to have available a simple expression or "rule-of-thumb" that could be employed to forecast the general level of impulse noise anticipated in new systems and concepts as a function of forecast basic physical characteristics. Predictions of far field levels as they might apply to personnel in the general firing area would also be useful and are reportedly amenable to computer solution; however, the primary area of interest must be considered to be the gunner's immediate area. It is intended, therefore, to provide an expression which will predict the peak pressure level at the gunner's head location by using readily-determined or claimed weapon characteristics.

BACKGROUND

Noise limits for Army materiel are specified in MIL-STD-1474A[1]. This standard sets forth impulse-noise limits for shoulder-launched rocket systems. These limits are expressed as peak pressure level or peak pressure, and pressure envelope duration (sometimes referred to as B-duration), and are defined by MIL-STD-1474A as follows:

—Peak Pressure Level (PPL)- The highest level, in dB, achieved.

—Peak Pressure (P_p)- The highest level, in psi, achieved.

—B-Duration- The total time that the envelope of pressure fluctuations (positive and negative) is within 20 dB of the PPL. Included in this time is the duration of that part of any reflection pattern that is within 20 dB of the PPL.

The above definitions are further defined graphically in Figure 1.

METHOD

PPL's at the gunner's head position, as measured for various proposed and developed shoulder-launched rockets were examined. It was assumed that PPL is correlated with muzzle velocity and, to a lesser extent, with the weight and diameter of the expelled round. It was also assumed that the PPL is inversely related to the distance from the gunner's head or ear to the rear of the launch tube. This latter assumption was felt to be extremely important, based on subjective auditing of long and short launchers while firing them, and while observing their being fired from offset locations. Finally, it was assumed that the distance from the gunner's ear to the breech of the launch tube (and front of the launch tube) is sufficiently related to the overall tube length to enable the latter design parameter (which is more readily available) to serve as an element in predicting PPL's.

[1]Department of Defense. Noise limits for Army materiel. MIL-STD-1474A(MI), Washington, DC, March 1973.

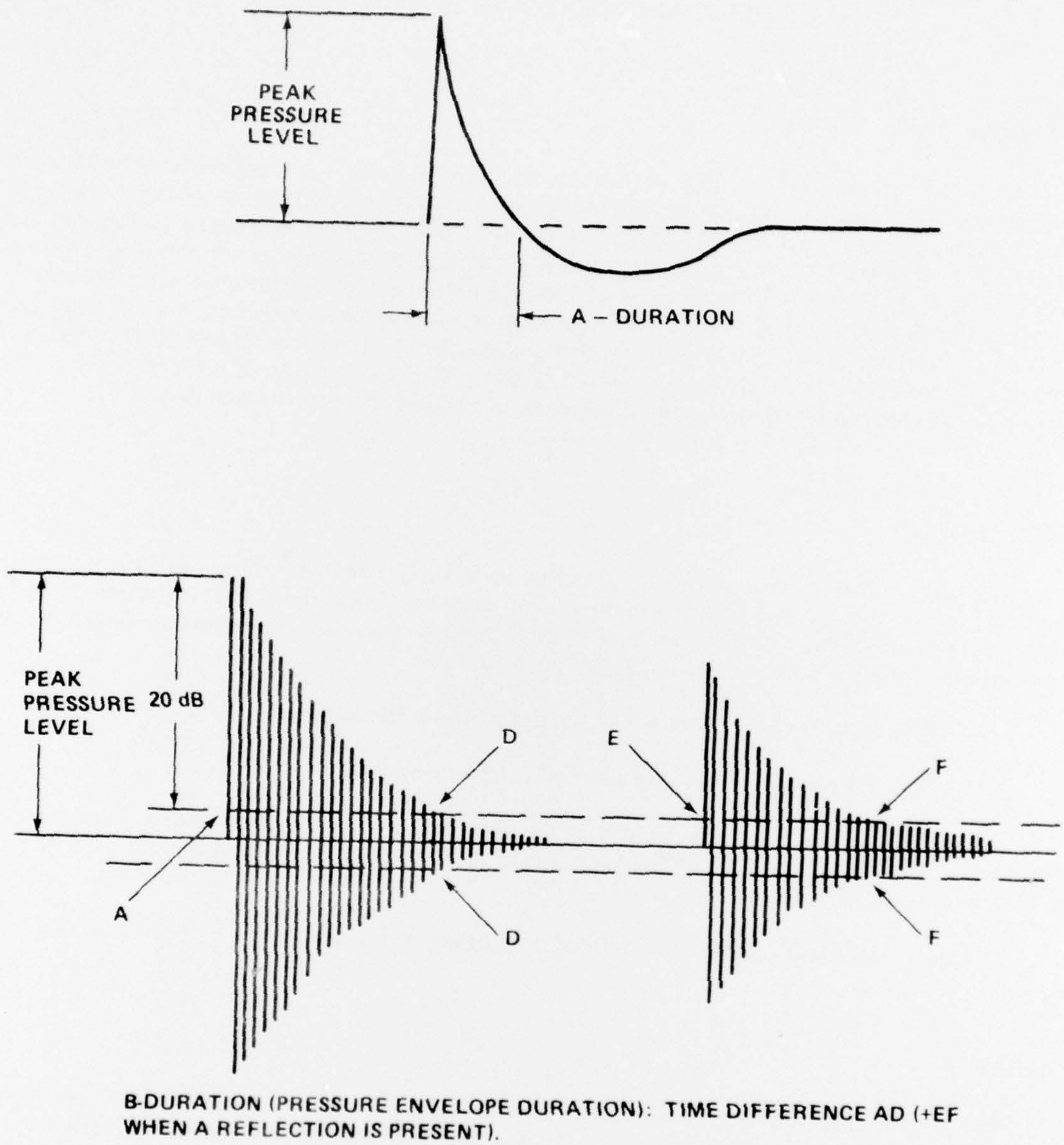


Figure 1. Idealized pressure-time history of an impulse noise (from MIL-STD-1474A(MI).

The above assumptions were used to develop a simple equation yielding peak pressure relationships for three systems with known characteristics and recorded PPL measurements. A few minor adjustments were then applied so that results correlated within a dB or two with the reported PPL's. Projectile weight, muzzle velocity, launcher length and diameter data for other systems were obtained from project personnel, available publications, or current measurement programs, and "plugged into" the equation. As a matter of curiosity, data from a recoilless system was also used. All values so obtained were rounded prior to inserting them into the equation.

RESULTS

The expression developed by the foregoing trial-and-error method was:

$$P_p = \frac{2.3V\sqrt{WD}}{L^2}$$

where: P_p = Peak Pressure (psi)
V = Muzzle Velocity (ft/sec)
W = Projectile Weight (prefire) (lb)
D = Launch Tube Inner Diameter (in)
L = Launcher Length (in)

Peak pressure was then converted to PPL in dB, using Figure 2. Results are shown in Table 1.

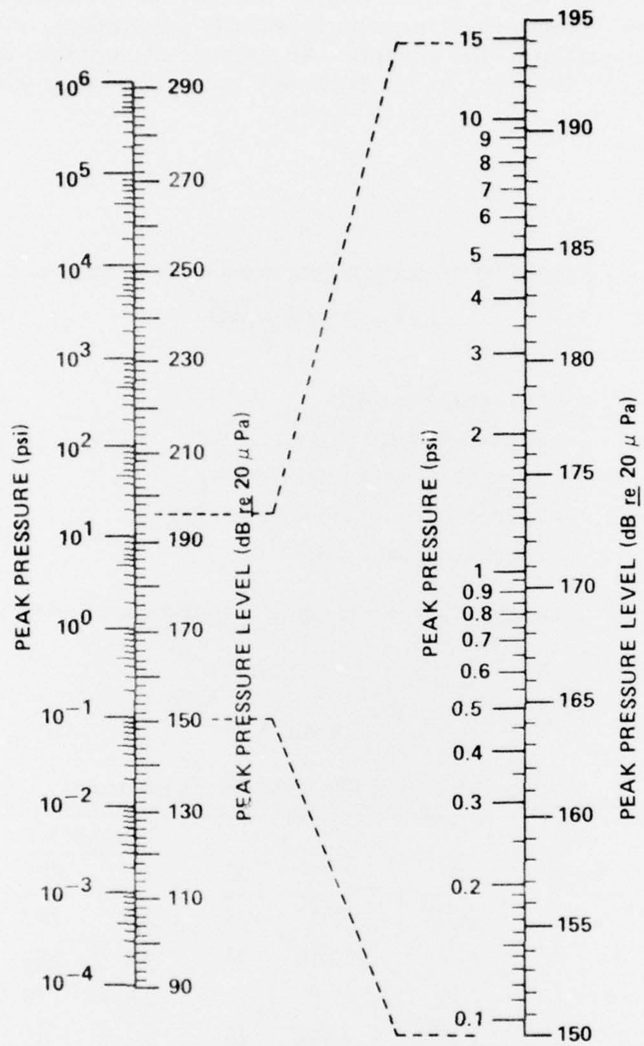
TABLE 1

Computation of PPL at Gunner's Location

System	W	D	V	L	Computed P_p	Computed PPL	Actual PPL	DIFF
I LAW	4	2-3/4	875	43	3.6	182	185	-3
DRAGON	14	5	250	37	3.5	182	185	-3
System A[a]	-	-	-	-	2.3	178	181	-3
SMAWT	5	2-3/4	850	48	3.1	181	180	+1
LAW	3.5	2-3/4	450	35	2.6	179	179	0
M202	3	2-3/4	375	35	2.0	177	175	+2
TOW	39	5	250	66	1.8	176	175	+1
STINGER	20	2-3/4	125	60	0.6	166	165	+1
90mmRR[b]	25	3-1/2	700	60	4.2	183	181	+2

[a]Foreign system. Parameters intentionally omitted.

[b]The values for the 90mm recoilless rifle were inserted only for general interest as the weight was merely estimated and the weapon is not a rocket system. Values for REDEYE were not inserted since little confidence is placed on available measurement results (158 dB) of fifteen years ago, using instrumentation of the period.



GIVEN: 1 psi = 6.895×10^3 Pa AND $\mathrm{dB} = 20 \log_{10} \dfrac{p_{peak}}{20\mu\ \mathrm{Pa}}$

THEN: $\mathrm{dB} = 20 \log_{10} \dfrac{\mathrm{psi}\ (6.895 \times 10^3\ \mathrm{Pa})}{20\mu\ \mathrm{Pa}} = 20 \log_{10} (\mathrm{psi} \times 3.4475 \times 10^8)$

Figure 2. Nomogram for conversion between psi and dB (from MIL-STD-1474A(MI).

In a similar manner the same expression, multiplied by twenty, was applied to the system parameters in metric format (Table 2) as follows:

$$P_p = \frac{46V\sqrt{WD}}{L^2}$$

where: P_p = Peak Pressure (psi[a])

V = Muzzle Velocity (m/sec)

W = Projectile Weight (prefire) (kg)

D = Launch Tube Inner Diameter (cm)

L = Launcher Length (cm)

TABLE 2

Computation of PPL at Gunner's Location

System	W	D	V	L	Computed P_p	Computed PPL	Actual PPL	DIFF
I LAW	1.81	7	267	109	3.7	182	185	-3
DRAGON	6.35	12.7	76	94	3.6	182	185	-3
System A[b]	-	-	-	-	2.3	178	181	-3
SMAWT	2.27	7	259	122	3.2	181	180	+1
LAW	1.59	7	137	89	2.7	179	179	0
M202	1.36	7	114	89	2.0	177	175	+2
TOW	17.69	12.7	76	168	1.9	176	175	+1
STINGER	9.07	7	38	152	0.6	166	165	+1
90mmRR[c]	11.34	9	213	152	4.3	183	181	+2

[a]P_p Dimensions are in customary units, rather than in metric units, to facilitate use of Figure 2 of MIL-STD-1474A *to obtain PPL directly from PSI. Follow-up work will focus on PPL expressed* in metric units at such time as Figure 2 of MIL-STD-1474A is revised to reflect metric units for P_p.

[b]Foreign system. Parameters intentionally omitted.

[c]See footnote for Table 1.

DISCUSSION

Comparison of the calculated PPL's with the measured PPL's of shoulder-launched rockets as presented by Tables 1 and 2, discloses fairly close correlation—within +2/-3 dB. It would appear that this is sufficiently close for the presented impulse noise expressions to be used to get a "ballpark figure" forecast of PPL at the gunner's position for new systems and thereby serve the purposes of (a) providing a reasonable prediction of the PPL when system parameters are

being selected, (b) setting initial calibration of instrumentation used during first measurements, and (c) serving as a reasonable challenge to launch noise claims of around 140 dB PPL by purveyors of very high velocity, short tube, large caliber concepts.

A caution which should be kept in mind when considering the PPL equation is that the previous measurements on which it is based were taken on systems where burnout occurs in the tube and no particular noise-attenuation devices are associated with the launchers (e.g., expansion chambers).

On the negative side, even if the equation presented can predict PPL to the degree of accuracy shown here, its use is rather limited since (a) noise limits for Army materiel are based on both PPL and B-duration, and (b) such forecasts would still be estimates assuming that acoustic environments of future systems are generated in the same manner as past systems.

The impulse-noise expression presented previously, while vulnerable to possible contradiction by later testing, forecasts the PPL of VIPER at 182 dB and the Advanced Multipurpose Missile System man-portable and crew-served versions at 178- and 177-dB, respectively, assuming no major configuration changes from current concepts.

CONCLUSIONS

The equation presented herein is a simple expression amenable to pencil-and-paper calculation and yields PPL's within about 3 dB for systems actually measured. It is not unreasonable to assume that the expression can provide a rough estimate of PPL to be expected from current and future system concepts, providing that their general configuration affecting noise generation are similar to those seven shoulder-launched systems examined here. Utility of the expression is, naturally, subject to confirmation or discard as dictated by future system tests.

RECOMMENDATIONS

The equation should tentatively be considered only as a very general indicator of expected PPL under temperate conditions or as a comparison device for assessing PPL claims for shoulder-launched systems which have not been subjected to measurement. Its use for single-number PPL predictions (as we have done at the end of the Discussion section) should probably be avoided.

These expressions are based upon empirical data and were not derived through in-depth theoretical considerations; they appear to provide a peak pressure level accuracy of ± 3 dB. It is hoped, in the future, that a more scientific approach may provide greater precision and be based on a more sound theoretical basis.